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Division of Agricultural Sciences

UNIVERSITY OF CALIFORNIA

ECONOMIES OF SCALE IN LARGE COMMERCIAL FEEDLOTS

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CALIFORNIA AGRICULTURAL EXPERIMENT STATION
GIANNINI FOUNDATION OF AGRICULTURAL ECONOMICS

Giannini Foundation Research Report No. 251

March 1962

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FOREWORD

This study of the economies of scale in large commercial feedlots is one phase of work being carried out by the California Agricultural Experiment Station under Western Regional Marketing Research, Project Number WM-37. The project is concerned with the economics of transportation of livestock and meats in the western region, relating particularly to the effects on the location of beef cattle feeding and slaughter. Research at California is currently underway on a spatial equilibrium analysis of the location of cattle feeding operations. A previously published report entitled Regional Supply and Distribution of Feed, 1957-58, Giannini Foundation Research Report No. 248, August 1961, provides a picture of the feed position of California and other regions of the country. Other research currently underway will provide information as to the economies of scale in beef slaughter plants.

The information included in this report on feed mill construction costs was provided by the Stohsner Machine Works, Inc., Napa, California, for which the author is deeply indebted. The study of large feedlots in Imperial Valley was undertaken in the summer of 1960, and the author expresses his appreciation for the excellent cooperation received from the feedlot operators. The field work was undertaken by Robert Rebholtz and Robert Muller. The author wishes to express his appreciation to H. O. Carter, J. Foytik, and B. C. French for their helpful comments in preparing this manuscript.

ECONOMIES OF SCALE IN LARGE COMMERCIAL FEEDLOTS

by

Gordon A. King[1]

INTRODUCTION

Cattle feeding in California is characterized by a high proportion of cattle fed in large commercial lots, as contrasted with the farm-feeding operations of the Midwest. On October 1, 1961, 98 percent of the cattle on feed in California were in feedlots with pen capacity of 1,000 head and over (see Table 1). Further, the importance of large feetlots has been increasing in recent years. The number of feedlots with pen capacity of 1,000 head and over reached 297 in 1961 as compared with 136 in 1953, whereas feedlots with under 1,000 head capacity have remained at approximately 300 over this period. The 1961 distribution of numbers of feedlots within the 1,000 head and over size category, as given below, illustrates the prevalence of large feedlots in the state.

Feedlot capacity number of head	Number of feedlots
1,000-2,499	160
2,500-4,999	64
5,000-9,999	34
10,000 and over	39

The operation of feedlots requires skillful management in the purchase of feed and feeder cattle and the sale of cattle; in the feeding operation to obtain an economically efficient feed conversion rate; in maintaining the health of the animals to minimize death loss; and in the utilization of a feed mill and yards that have high investment costs. For a given utilization of the fixed plant, Hopkin[2] has indicated that the average daily nonfeed costs per animal day decline substantially as the size of the feedlot increases from a level of 1,000 head fed per year to a level of 50,000. This is an important reason underlying the trend toward larger feedlots. An important

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[1] Associate Professor of Agricultural Economics and Associate Agricultural Economist in the Experiment Station and on the Giannini Foundation, University of California, Davis, California.

[2] Hopkin, John A., "Economies of Size in the Cattle-Feeding Industry of California," Journal of Farm Economics, Vol. 40, No. 2, May 1958, pp. 417-429.

TABLE 1

Trends in Number of Feedlots in California by Size, Total Feedlot Capacity, and Number of Cattle on Feed October 1, 1953-61 a/

Year	Number of feedlots			Total capacity		Cattle on feed	
	Total	Capacity of: feedlot					
		0-999	1,000 and over	Total number of head	Percent in feedlots with capacity of 1,000 and over	Total number of head	Percent in feedlots with capacity of 1,000 head and over
	number			thousand	percent	thousand	percent
1952	447	311	136	624	85	307	92
1954	507	368	139	655	85	433	90
1955	530	--	--	790	--	498	90
1956	551	357	194	860	87	519	92
1957	535	332	203	924	89	459	92
1958	529	318	211	944	89	474	93
1959	526	284	242	1,084	91	636	96
1960	559	281	278	1,271	92	761	97
1961	602	305	297	1,399	92	754	98

a/ Data on number of feedlots by size and capacity of feedlots relate to January 1 for 1953-58 and to October 1 for 1959-61; and to October 1 data for cattle on feed for all years.

Source: California Livestock, California Crop and Livestock Reporting Service, Sacramento, California.

characteristic of many large feedlots, however, is the relative importance of custom feeding done for cattle producers and packers, as compared with the small feeders with feedlot capacity of less than 1,000.[1] In custom feeding, the feedlot operator charges the owner of the cattle for the quantity of feed fed with the cost per ton varying with the ration or rations desired by the owner, plus additional yardage charges often quoted on the basis of a cost per ton fed or cost per head per day.

The advantage of custom feeding to the producer of feeder cattle is in having skilled management in feeding out the cattle to market weight and in having a ready "market" for the animals, since packer buyers make frequent visits or phone calls to the feedlots. The advantage of custom feeding to the packer is in an assured supply of slaughter weight cattle which is an important aspect in the efficient operation of a slaughter plant. The cattle feeder has a potential advantage in custom feeding some proportion of cattle fed in that the lower nonfeed costs associated with a large-scale operation may be obtained without the price risk associated with the purchase and sale of that number of cattle. Although death losses are not a direct cost to the custom feeder, his reputation depends on the ability to keep losses at a minimum as well as to obtain economically efficient feed conversion rates. Whether the feedlot operator is feeding his own cattle or custom feeding, it is important to have information as to how nonfeed costs vary with the number of cattle fed.

The objectives of this study are to determine how nonfeed costs vary depending on the utilization of a given sized feedlot, and to determine how costs vary with the size or capacity of the feedlot. The study does not consider other possible cost advantages associated with size, such as volume purchases of feed and cattle, or possible price advantages in the sale of cattle if such exist. The information developed should be of value to those interested in developing new feedlots or in expanding present feedlot size, as well as those concerned with costs associated with varying the utilization of the present feedlot capacity.

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[1] Data from a sample of California feedlots with capacity of 1,000 head or less, indicate that 87 percent of the operators feed only their own cattle; 1 percent custom feed only; 10 percent feed their own cattle plus custom feed; and 2 percent did not specify; as reported in: Wright, Gene, and Thomas M. Stubblefield, Marketing Cattle and Calves from Small Feedlots in Arizona and California, Arizona Agricultural Experiment Station Report No. 194, November 1960.

METHOD OF ANALYSIS

The approach used in this analysis of nonfeed costs of commercial feedlots parallels that employed in previous studies of the economies of scale in the production of agricultural products or marketing services.[1] This approach involves estimating cost-output relationships for a selected number of hypothetical plants, in this case feedlots, that differ as to scale. In this section of the report, terminology and assumptions of the analysis are defined and research procedure is outlined.

Analytical Framework

The basic goal of economies of scale studies is to determine the nature of long-run average unit cost curves which relate average cost to output per time period. This curve, as illustrated in Figure 1, section A, is obtained by drawing an "envelope" curve to a series of short-run cost curves in which the scale of plant is held fixed. Scale of plant refers to a particular output per unit of time, which is that output at which short-run average costs are at a minimum. In conventional theory, the short-run cost curves are "u" shaped, with average unit costs increasing at outputs greater than that associated with the minimum cost output. Reasons for increased costs per unit of output include such factors as the necessity of overtime payments to labor when plants are operated over a

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[1] For example, see: Boles, J. N., "Economies of Scale for Evaporated Milk Plants in California," Hilgardia, Vol. 27, No. 21, October 1958.

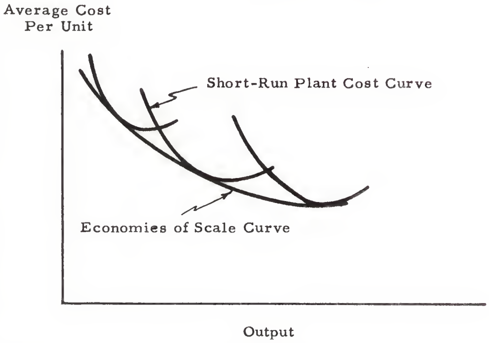
Bressler, R. G., Jr., Economies of Scale in the Operation of Country Milk Plants, New England Research Council on Marketing and Food Supply in cooperation with the New England Agricultural Experiment Stations and the U. S. Department of Agriculture, 1942.

French, B. C., L. L. Sammet, and R. G. Bressler, "Economic Efficiency in Plant Operations with Special Reference to the Marketing of California Pears," Hilgardia, Vol. 24, No. 19, July 1956.

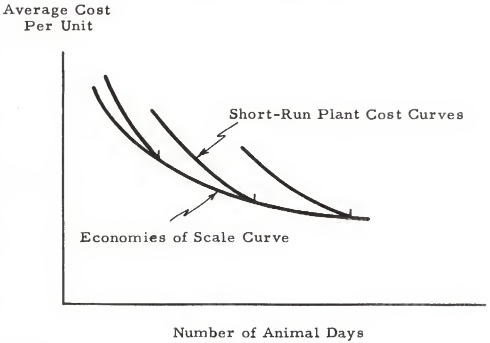
Farrish, R. O. P., and S. K. Seaver, Factors Affecting the Output, Size, Costs and Location of Poultry Plants in Southern New England: I. Costs Efficiency and Economies of Scale in Broiler Processing Plants. Storrs Agricultural Experiment Station Bul. 342, September 1959.

Figure 1. Hypothetical Short-Run Plant Cost Curves and Economies of Scale Curve

Section A: Conventional Short-Run Cost Curves



Section B: Short-Run Cost Curves of This Study



given number of hours per day. In this study, output and scale are defined such that output beyond the point of minimum average cost on the short-run cost curve are not relevant, and the curves become discontinuous at that level of output. (See Figure 1, section B.)

Output of a feedlot may be defined in terms of the number of animal days, or the total number of cattle fed per year (N) multiplied by the average number of days on feed per head (d); or

(1) $\text{Output} = Nd.$[1]

The output of a particular feedlot (Nd) varies with the number of cattle on feed at a given time and the days of feedlot operation per year, subject to the restraint of the designed capacity of the feedlot; or

(2) $Nd = nD$ where $n \leq C$,

where N = number of cattle fed per year,

d = number of days on feed per head,

n = average number of cattle on feed at a given time,

D = number of days of operation per year; $D \leq 360$,

C = designed capacity of the feedlot (defined below).

The number of cattle on feed at a given time is the summation of the number in various lots of cattle that are on feed. For simplification, it is assumed that only one lot of cattle is on feed at a given time. Also, it is assumed that the feedlot is operated only 360 days per year, allowing time for moving cattle in and out of the lot.

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[1] This measure of output is equal to that obtained by adding the number of days each animal is on feed (d_i); or output = $\sum_{i=1}^{n} d_i = Nd$. In actual feedlot operations, the number of days on feed varies among lots of cattle. The use of average number of days on feed (d) in the cost relationships developed in this report may introduce some minor error since more time is required for handling cattle when fed 110 days than when fed 180 days. Thus, costs per animal day might be slightly higher for the animals fed the shorter period, assuming equal utilization of feedlot capacity.

The designed capacity of a feedlot (C) relates to the maximum number of cattle that may be placed on feed at a given time. The capacity depends on the size of the feed yards and feed mill. In developing the hypothetical model feedlots for this study, the size of feed mill was established for each feedlot and other investment costs coordinated with the relevant mill output per hour, assuming that at capacity the mill would be operated 10 hours per day.

Feed mills were designed for output rates of 5, 10, 15, 20, and 30 tons per hour for a ration consisting of about 75 percent concentrate feed and 25 percent roughage and premix. Variation in the composition of the ration will, of course, change the output per hour to some extent. The capacity of the feedlot then is related to the mill output per hour (r), the number of hours operated per day (h), and the amount of a particular ration fed per day (f). We may then define the capacity of the feedlot (C) in relation to these three variables as follows:

$$C = \frac{rh}{f}, \tag{3}$$

where C = maximum number of head on feed at a given time,
r = mill output per hour in tons of a specified ration,
h = hours of mill operation per day,
f = feed fed per head per day in tons of a specified ration.

The amount of feed fed per head per day and the composition of the ration fed are changed in actual feedlot operations depending upon such considerations as age and weight of the animal, the price of the feeds included in particular ration in relation to the expected feed conversion efficiency, and the expected price of carcass beef. In this study, cost relationships of nonfeed costs are developed for a specified ration but results obtained may be modified readily to apply to other situations. It is assumed here that cattle are fed an average of 26.6 pounds of mixed feed per day of the following composition:[1]

	Percent
Barley or milo	55
Cottonseed meal	10
Molasses	10
Premix and roughage	25
	100

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[1] This ration is based on rations reported in use by Imperial Valley dry-lot feeders in 1960.

With this ration, the value for (f) in equation (3) equals .0133 (i.e., 26.6 pounds per day per head, divided by 2,000 to convert from pounds to tons).

The capacities of the model feedlots are then developed directly from the relationship in equation (3) with the value of $h = 10$ and $f = .0133$. For example, the model feedlot with mill output per hour of 10 tons ($r = 10$), has a capacity (C) of 7,520 head.

The amount of feeding pen space required for a given number of cattle may vary with the weight of the animal, the ration fed, and with the season of the year in areas where weather conditions are an important consideration. To develop general relationships, the amount of pen space was assumed as constant for all feedlots at 220 square feet of loafing space per head and 2 feet of manger feeding space per head. Total pen space requirements for the model feedlots were then estimated to correspond with the capacity of the feed mill as developed above. Increased number of animals could be placed in the feeding pens; however, at certain levels of crowding, death losses undoubtedly would increase. Thus, the use of standard space requirements allows comparability among feedlots of different sizes and for feedlots operated at varying levels of capacity.

Procedure

The approach used in this study involves constructing hypothetical model feedlots and determining costs of operation for various levels of output. The designed capacity, as noted above, is related to the size of feed mill with feeding pens and other investments coordinated with the number of animals that could be fed with 10 hours of mill operation. Feedlot designed capacity thus is stated in terms of the number of animals that can be fed at a given time. The procedure used in developing costs may be summarized briefly as follows:

1. Specify five model feedlots with designed capacity of 3,700; 7,520; 11,280; 15,040; and 22,000 head of cattle, respectively.
2. Determine investment requirements in feed yards, feed formulating equipment and buildings, feeding and miscellaneous equipment, and feed storage buildings for each of the model feedlots.

3. Determine physical requirements for such inputs as labor and electricity when the feedlots are operated at full capacity for the year.

4. Determine the costs associated with operating the feedlot at full capacity for the year.

5. Determine how these costs vary for the individual feedlots when operated at various levels of output.

Information regarding requirements for equipment, labor, and various other input data was obtained from a sample of 12 large feedlots located in Imperial Valley, California. Feed mill construction costs were obtained from a feed mill construction firm for outputs ranging from 5 to 30 tons per hour. Although the level of costs may differ from one area to another, the cost data are believed to adequately represent the relative level of costs for the various sizes of mills, the important consideration in this study. Other investment costs for such items as the feed corrals were also developed, as will be explained in detail.

Costs of operating the model feedlots were synthesized based on data from the sample of feedlots and from other sources. For example, electricity costs were estimated by applying appropriate service and energy charges to the kilowatt-hour consumption levels developed for the various feedlots. Annual depreciation costs were estimated by applying a depreciation rate to the calculated investment costs. Labor costs were based on estimated man-hour requirements for feed mill operation, feeding, etc., and an assumed level of hourly wages. These costs were then checked for consistency with the level of costs obtained in the feedlot sample data. For such cost items as veterinary and medicine, cost estimates based directly on the Imperial Valley feedlot study were used.

CAPITAL INVESTMENT

Estimated investment requirements for the five model feedlots, as indicated in Table 2, range in cost from $51 per head designed capacity for the low-capacity lot to $34 for the high-capacity lot. Investment is classified into five major categories: (1) the feed formulating equipment and buildings, (2) feeding and miscellaneous equipment, (3) the feed yard,

TABLE 2

Investment Costs for Model Feedlots[a]

Item	Designed capacity (C)--in number of head [b]				
	3,760	7,520	11,280	15,040	22,560
	dollars				
Feed formulating equip. & bldg.	70,650	83,550	97,650	114,550	145,450
Feeding & misc. equip.	17,190	17,610	29,880	29,900	42,650
Total	87,840	101,160	127,530	144,450	188,100
Feed yard	75,000	150,000	225,000	300,000	450,000
Grain & hay storage	20,500	41,000	61,500	77,200	115,800
Office & scales	9,810	10,500	16,000	16,000	16,000
Total	105,310	201,500	302,500	393,200	581,800
Total investment	193,150	302,660	430,030	537,650	769,900
Investment per head capacity	51.37	40.25	38.12	35.75	34.13

[a] For a more complete description of investment costs, see Table 3 and Appendix Tables B3-B6.

[b] The designed capacities relate to feedlots with feed mill output of 5, 10, 15, 20, and 30 tons per hour operated 10 hours per day.

(4) hay and grain storage facilities, and (5) the office and scales for feed and livestock. Investment in feed yards and feed formulating equipment and building account for three-fourths of total investment. Investment in feed yards accounts for the largest proportion of total investment for all model feedlots, with this proportion increasing with the size of feedlot. Investment in the feed mill is the second major investment item, but this cost accounts for a smaller proportion of total investment as feedlot size increases.

Feed Formulating Equipment

Feed mills with output per hour of 5, 10, 15, 20, and 30 tons, respectively, were specified for the model feedlots. The lot capacity was then estimated for the number of head that could be fed from the output of the mill operating 10 hours per day. The length of day was the maximum reported in the sample of feedlots in Imperial Valley,[1/] with a reported range of 2-10 hours of operation. Percentage mills were specified for the model feedlots, although the batch system also is used in large feedlots.

The investment in the feed mill and other items is given in Table 3 for the feedlot with capacity of 7,520 head and mill output of 10 tons per hour. Companion tables for investment in the other four model feedlots are given in Appendix Tables B3 - B6.

Equipment included in this category includes a hay mill and conveyor, grain roller and conveyor, the percentage mill including premix equipment, molasses blending equipment, finished feed bins, and grain elevator and conveyors. The finished feed bins are specified to hold enough feed for one hour's output of the mill, and feeding labor is coordinated such that this would be sufficient storage capacity. Molasses storage tanks, included in this category, have capacity for a two weeks' supply.

Feeding and Miscellaneous Equipment

Equipment for feeding livestock is specified as automatic feeders mounted on trucks. The number of trucks and capacity of the automatic

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1/ See Appendix Table B1.

TABLE 3

Investment Costs for Feedlot with Designed Capacity of 7,520 Head and Feedmill with 10 Tons Per Hour Capacity

Item	Number	Description	Capacity	H. P. of motors	Total cost dollars
Feed yards	--	Cost approx. $20/head cap.	7,520 head	--	$150,000
Grain and hay storage					
Grain	--	Cement floors	2,400 T	--	36,000
Hay	--	Pole and timber constr.	500 T	--	5,000
Total					41,000
Office and scales					
Office	--	--	--	--	4,500
Scales, livestock	1	8' x 22'	10 T	--	1,500
Scales, truck	1	10' x 30'	25 T	--	4,500
Total					10,500
Feed formulating equipment and buildings					
Hay mill and conveyor					
Mill and conveyor	1	30" mill, precutter, baled hay & chopped hay conveyors, dust collector and building	4-5 T/hr.	95 1/2	14,300
Dust collector	1			1	6,000
Grain conveyor from storage					
Bucket elevator	1	--	30 T/hr.	5	3,500
Distributing head	1	6 way head	--	--	1,000
Elevator pit	1	--	--	--	2,500
Auger	4	--	30 T/hr.	8	6,250
Grain roller and blower					
Roller	1	30"	4-6 T/hr.	40	6,400
Blower	1	9"	--	15	2,200
Percentage mill					
Concentrate bins (28 T)	4	Including motors for feed delivery	3-9 T/hr.	3/4	13,900
Hay bin (4 T)	1	Including motors for feed delivery	1-6 T/hr.	3/4	
Collecting auger	1	--	5-15 T/hr.	1/2	1,000
Premix bin	1	Including motor for feed delivery	1/4 T/hr.	1/4	700
Premixer	1	Including motor	250 lbs.	1 1/2	700
Premix bucket elevator and scale	1	--	--	1/2	1,000
Tachometer	1	--	--	--	1,200
Molasses blending, feed conveyors, and finished feed bins					
Tank, pump, etc.	1	--	10,000 gal.	3/4	4,100
Hot water coil and heater	1	Incl. circulating pump	--	1/2	1,400
Dry feed elevator	1	Moves feed-dry blender to surge bin	--	1 1/2	2,300
Surge bin	1	--	5-10 T/hr.	3/4	1,800
Wet blender	1	--	10 T/hr.	10	1,500
Blending room	1	--	--	--	4,000
Finished feed elevator	1	--	5-10 T/hr.	2	2,500
Finished feed bins	2	5 ton/bin	10 T	--	5,000
Bin meter	2	--	--	--	300
Total					83,550
Feeding and miscellaneous equipment					
Livestock squeeze	1	--	--	--	450
Sprayer	1	--	100 gal.	--	660
Pickup truck	1	--	--	--	2,200
Feeding trucks					
Truck	1	--	2 T	--	3,400
Automatic feeder	1	370 cu. ft.--mounted on truck	--	--	3,000
Tractor and scoop	1	--	40 h. p.	--	5,000
Hay trailers and loader	1	--	--	--	2,900
Total					17,610
TOTAL					$302,660

feeders vary among model feedlots depending on the quantity of feed fed. It is assumed that feed truck drivers can make two trips per hour from the mill to the feeding area, feeding about 10 tons per hour per driver, or 750 cattle per hour per man.

Feed Yards

Investment in feed yards varied between $7 and $30 per head capacity with an average of $19 for the sample of feedlot operators in Imperial Valley. To allow for direct comparability between feedlots of varying size, a standard construction was specified. Actual costs of feedlot construction vary with the construction material used, the loafing space required, the manger feeding space per head, requirements for shade, the need for cement paving in the truck feeding lane, and other factors. The cost estimate used in this study is $20 per head capacity for all lot sizes, based on considerations given in detail in Appendix A.

Grain and Hay Storage

Considerable variation in the amount of grain storage capacity was reported for Imperial Valley feedlots, ranging from one week's supply to over five months. For purposes of this study, the storage capacity for grain and hay was specified at one month's supply for mills operated at 80 percent of capacity, or eight hours per day. Investment costs are indicated in Table 3 for the feedlot with capacity of 7,520 head and in comparable tables in Appendix Tables B3-B6 for the other model feedlots.

Office and Scales

An office is specified for each of the model feedlots. The size of the livestock and truck scales was varied among feedlots depending on the size of operation. The description and cost of this equipment is given in Table 3 for feedlot with capacity of 7,520 head, and in Appendix Tables B3-B6 for the other model lots.

ESTIMATION OF FIXED AND VARIABLE COSTS

Costs are divided into those that are fixed in total amount for a year for a given size of feedlot regardless of the number of cattle fed, and variable costs, or those costs that vary with the number fed. For purposes of this analysis, fixed costs include management, office, taxes other than on livestock, insurance, interest, depreciation on equipment, and depreciation and repair on the feed yard, office, scales, and grain and hay storage. The variable cost items include labor other than office, electricity and water, telephone, gas and oil, veterinary and medicine, miscellaneous supplies, and equipment repairs, and death loss.

Fixed Costs

Management, Including Office

The cost for management and office was assumed to be roughly proportional to the number of head capacity of the five model feedlots. The number of men required was based on information obtained from the sample of feedlots. Management is difficult to specify since there are important differences among feedlots as to the time spent in buying and selling of cattle and purchase of feed. Without data to justify differences in the efficiency of management as such, a constant level of annual salary was assumed for the five model feedlots, but numbers of workers were varied in proportion to lot capacity. Management and office expenses are indicated in Table 4.

Taxes, Interest, and Insurance

Taxes were estimated at 1 percent of the total investment in plant and equipment. A similar level of cost (1 percent of total investment) was estimated for insurance. The charge for interest was estimated at 3 percent of total investment. These annual costs are given in Table 4 for the five model feedlots.

Depreciation on Equipment

Depreciation on the feed formulating equipment, feed trucks, grain conveying equipment, and miscellaneous other equipment was estimated at 5 percent

TABLE 4

Annual Fixed Costs for Five Model Feedlots

Item	Designed capacity (C)--in number of head				
	3,760	7,520	11,280	15,040	22,560
	dollars				
Management & office[a]	8,500	15,000	22,500	30,000	42,500
Taxes, insurance & interest[b]	9,658	15,133	21,502	26,882	38,495
Equipment depreciation[c]	4,392	5,058	6,376	7,222	9,405
Depreciation & repair of other investment d/	7,372	14,105	21,175	27,524	40,726
Total	29,922	49,296	71,553	91,628	131,126

a/ The model feedlot with 7,520 head capacity is considered the base for comparison of management and office costs. The office cost represents the annual wages of 1 full-time employee paid $5,000 per year. The management cost represents the annual wages of 1 full-time manager paid $10,000 per year. Costs for other model feedlots are approximately in proportion to size.

b/ Taxes and insurance each are estimated at 1 percent of the total original investment. Interest on investment is estimated at 3 percent of total original investment. Investment for each model feedlot is shown in Table 2.

c/ Equipment depreciation is estimated at 5 percent of the original investment in feed formulating equipment and buildings, feeding equipment and miscellaneous equipment. (See Table 2.) Equipment repair is included as a variable cost.

d/ Depreciation and repair of other investment is estimated at 7 percent of the original investment in feed yards, grain and hay storage buildings, office, and scales. (See Table 2.)

of investment. The repair costs on equipment were assumed to vary depending on the hours of use per year, and are included under variable costs. The investment cost for feed formulating equipment includes the cost of the building which might well have been included under plant investment for purposes of estimating depreciation. However, the amount of error introduced is negligible.

Depreciation and Repairs on Other Investment

The feed yard, grain and hay storage, office, and scales were depreciated at a rate of 5 percent, plus a repair and maintenance cost of 2 percent of investment. These costs are given in Table 4.

Variable Costs

Variable costs include labor other than office, electricity, equipment repairs, gas and oil, veterinary and medicine, telephone, and death loss. In custom feeding, death loss is not a cost to the feedlot operator and should be deducted from costs.

Annual total variable costs are related to output measured in terms of animal days (Nd). However, for some cost items it is more relevant to express costs as a function of total tonnage of feed fed. Since the amount of feed fed per head per day is assumed as constant in this analysis, it is possible to convert directly from costs expressed as a function of tons of feed fed to costs expressed as a function of animal days. This relationship follows directly from equation (3) in which daily feed mill output (rh) is expressed as a function of the number of head on feed at a given time (n). With the assumed value for f (f = .0133) this expression is as follows:

$$(4) \qquad rh = .0133\ n \leq C$$

The annual feed output is obtained by multiplying the daily feed output (equation 4) by the number of days operated per year (D), or

$$(5) \qquad T = .0133\ nD,$$

where $T = rhD$ = annual feed output in tons,

n = average number of head on feed at a given time,

D = number of days of operation per year.

From equation (2) we may replace nD by Nd and re-write equation (5) as follows:

(6) $$T = .0133\ Nd.$$

This relationship is useful in developing variable costs in this and subsequent sections since some costs are more closely associated with the tonnage produced (e.g., mill repair costs) and others are more closely associated with the number of days on feed (e.g., veterinary costs).

Labor, Excluding Office

Labor costs were developed by applying hourly wage rates to estimated man-hour requirements for the feed mill operation, cattle feeding, etc. Labor requirements in terms of man-hours are shown in Table 5 for the model feedlots operated on a 10-hour day. These data were based on information obtained from the Imperial Valley Study, but must be considered as approximations since no detailed study of labor time requirements was made as such. Labor requirements for feedlots operated at less than capacity are assumed to vary directly with the number of hours of mill operation. This assumption tends to underestimate labor costs for feedlots operated at less than capacity since workers would use time in shifting from one job to another to a greater extent than when the feedlot is operated at capacity. The labor requirements, shown in Table 5, may be expressed as follows:

(7) $$m = 10 + 0.63\ rh$$

where m = man-hours of labor per day,

10 = constant number of man-hours for mill foreman,

r = feed mill output per hour in tons,

h = hours of mill operation per day; $h \leq 10$.

The labor cost per day may be estimated from equation (7) for given wage rates. These rates, including workmen's compensation, social security, etc., are taken at a level of $2.00 per hour for the mill foreman and $1.65 per hour for other labor. Daily labor cost (c_m) for a 10-hour day may be expressed as follows:

(8) $$c_m = 20 + 1.04\ rh.$$

TABLE 5

Estimated Man-Hours of Labor for Model Feedlots with Mill Operated 10-Hours per Day

Item	Designed capacity (C)--in number of head [a]				
	3,760	7,520	11,280	15,040	22,560
	man-hours				
Feed mill					
foreman	10	10	10	10	10
other	20	35	50	70	100
Total	30	45	60	80	110
Cattle feeding[b]	5	10	15	20	30
Other[c]	10	20	30	40	60
Total	45	75	105	140	200

[a] Designed capacity for model feed mills operated 10 hours per day with rate of output of 5, 10, 15, 20, and 30 tons per hour respectively. The number of cattle fed per day is related to daily feed mill output assuming cattle are fed 26.6 pounds of a specified ration per day.

[b] Assuming one man operating a truck-mounted automatic feeder with capacity of 5 tons of mixed feed can feed 10 tons per hour or 750 cattle per hour.

[c] Includes time for handling feed and cattle.

The annual labor cost is obtained by multiplying equation (8) by the number of days operated per year (D). With D = 360 and rhD = T, we may express annual labor cost as follows:

$$(9) \qquad C_m = 7{,}200 + 1.04\ T$$

where C_m = annual labor cost in dollars,

T = annual feed output in tons.

Annual labor costs may be expressed as a function of the number of animal days (Nd) by substituting the relationship given in equation (6) for T in equation (9) as follows:

$$(10) \qquad C_m = 7{,}200 + 1.04\ (.0133\ Nd),$$

$$= 7{,}200 + .01383\ Nd.$$

The synthesized labor cost function (10) provides cost estimates reasonably in line with those obtained from a regression analysis of the sample feedlot data.[1] The synthesized costs are lower since they represent an efficient operation under standard conditions rather than a derived relationship based on feedlots of various capacities operated at various levels of capacity.

Electricity and Water

The annual cost of electricity including water pumping costs was obtained by applying appropriate energy charges to electricity consumption estimated on the basis of connected load and hours of use. Electricity consumption may be expressed as follows:

$$(11) \qquad C_{kwh} = s\ (HP)\ hD,$$

---

[1] The regression analysis of labor costs, excluding office, provided the following relationship:

$$C_m' = 8{,}567 + 0.01496\ Nd$$

$$r^2 = .76;\ t = 5.0.\quad n = 9.$$

where C_{kwh} = kilowatt-hours used per year,

s = kwh per horsepower per hour,

HP = horsepower of connected load,

h = hours of mill operation per day; $h \leq 10$,

D = number of days of operation per year; $D \leq 360$.

The value of (s), the kwh consumption per horsepower per hour, was taken as 1.0 based on information provided by the electric company. The horsepower requirements for the feed mill were provided by the feed mill construction firm, and additional horsepower requirements for water pumping and lighting were then included. The horsepower requirements for the model feedlots were then expressed as a function of the feed mill output per hour (r) as follows:

$$HP = 90 + 13r. \tag{12}$$

Substituting the value for (s) and the HP into equation (11), we may express consumption of electricity as follows:

$$C_{kwh} = 1.0\ (90 + 13r)\ hD. \tag{13}$$

The rate structure for connected loads of 100HP and over for Southern California is given below:[1]

$$E_c = 6.50\ HP + HP(.0136c_1 + .0082c_2 + .0064c_3) \tag{14}$$

where E_c = annual cost for electricity in dollars,

C_1 = first 1,000 hours of use in kwh,

C_2 = second 1,000 hours of use in kwh,

C_3 = over 2,000 hours of use in kwh.

and $C_{kwh} = c_1 + c_2 + c_3$.

Annual electricity consumption was estimated from equation (13) for each of the model feedlots assuming operation 360 days per year (D = 360) and allowing number of hours operated per day (h) to vary between two and ten hours. Cost of electricity was calculated using equation (14). A functional relationship was then fitted for each of the model feedlots, expressing annual cost as a function of tons of feed fed (rhD). Results are summarized in Table 6.

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[1] Rates for Southern California Edison Company, Schedule PA 1 - Agricultural and Pumping, Connected Load Basis, Effective November 9, 1957.

Equipment Repairs

Annual equipment repair costs vary with the level of investment and with use. The investment in feed mill and feeding equipment is given in Table 2 for the five model feedlots. For a given feedlot, repair costs were assumed to vary in direct proportion to use as indicated below:[1]

Percent of maximum annual output	Repair allowance as a percent of investment
100	3.0
80	2.5
60	2.0
40	1.5
20	1.0

Annual repair costs were calculated for each of the model feedlots operated at varying levels of capacity. Cost functions summarizing these data are given in Table 7.

Gasoline and Oil

A charge of $0.0020 per head per day was used in this study corresponding to the average level indicated in the sample feedlot operations, as given in Appendix Table B2.

Veterinary and Medicine

Annual veterinary and medicine cost was based on a regression analysis of the sample data from Imperial Valley feedlots in which annual cost ($C_{v\&M}$) was expressed as a function of the number of animal days (Nd). The estimating equation is as follows:

$$C_{v\&m} = 3,336 + .00245\ Nd \qquad r^2 = .81$$

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[1] This method of treating repair costs is similar to that used by George B. Rogers and Edwin T. Bardwell, Marketing New England Poultry: Economies of Scale in Chicken Processing. New Hampshire Agricultural Experiment Station Bul. 459, April 1959, p. 14.

TABLE 6

Electricity Cost Functions for Model Feedlots

Item	Designed capacity (C)--in number of head				
	3,760	7,520	11,280	15,040	22,560
	dollars				
Constant term	1,850	2,626	3,405	4,178	5,731
Cost per ton of feed (T)	.23556	.16722	.14435	.13306	.12162
r^2	.99	.99	.77	.99	.99
t	15.9	15.9	2.4	16.2	34.4
Cost per animal day (Nd)[a/]	.00313	.00222	.00192	.00177	.00162

[a/] Calculated by multiplying the cost per ton of feed by .0133. (See equation 6.)

TABLE 7

Equipment Repair Cost Functions for Model Feedlots

Item	Designed capacity (C) in number of head				
	3,760	7,520	11,280	15,040	22,560
	dollars				
Constant term	446	502	638	722	940
Cost per ton of feed (T)	.12160	.07041	.05907	.05014	.04352
r^2	.99	1.00	1.00	1.00	1.00
t	9.9	∞	∞	∞	∞
Cost per animal day (Nd)[a/]	.00162	.00094	.00079	.00067	.00058

[a/] Calculated by multiplying the cost per ton of feed by .0133. (See equation 6.0.)

where $C_{v\&m}$ = annual veterinary and medicine cost in dollars,

r^2 = coefficient of determination.

Telephone

Annual telephone cost was based on a regression analysis of the sample data from Imperial Valley feedlots, in which annual cost (C_t) was expressed as a function of the number of animal days (Nd). The estimating equation is as follows:

$$C_t = 529 + .00025 \text{ Nd} \qquad r^2 = 49.$$

where C_t = annual telephone cost in dollars.

Death Loss

Death loss is estimated at 1 percent of the number of cattle fed. This corresponds to the average level reported in the sample feedlots. The cost is estimated by assuming that the average weight of animal lost equals 800 pounds, or about one-half way through a 120-day feeding period for a 600-pound steer. If a price of $25 cwt. is assumed for the animal, a cost of approximately $0.0166 per animal day is obtained.

Total Variable Costs

Cost relationships developed for each of the variable cost items are summarized in Table 8 for the five model feedlots. These data are the basis for the short-run total average cost curves presented in the following section.

The cost data presented in this report do not deduct a credit for manure. For some purposes it may be desirable to obtain a net cost for feeding operations, for which the following calculation may be useful. Hopkin indicates that manure produced in feeding operations averages between six and nine pounds per day per head.[1] The price per ton varied from $1.50 to $5.00 per ton depending on the kind of agriculture in the area, with highest prices received in areas where flowers, vegetables, or citrus fruits are

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[1] Hopkin, John A., Cattle Feeding in California, Economics Department, Bank of America, National Trust and Savings Association, San Francisco, California, February 1957.

TABLE 8

Annual Fixed and Variable Costs for Model Feedlots

Item	Designed capacity (C)--in number of head				
	3,760	7,520	11,280	15,040	22,560
	dollars				
Fixed cost	29,922	49,296	71,553	91,628	131,126
Variable cost					
constant term					
labor	7,200	7,200	7,200	7,200	7,200
electricity	1,850	2,626	3,405	4,178	5,731
equipment repairs	446	502	638	722	940
veterinary & medicine	3,336	3,336	3,336	3,336	3,336
telephone	529	529	529	529	529
Total	13,361	14,193	15,108	15,965	17,736
cost per animal day (Nd)					
labor	.01383	.01383	.01383	.01383	.01383
electricity	.00313	.00222	.00192	.00177	.00162
equipment repairs	.00162	.00094	.00079	.00069	.00058
gasoline & oil	.00200	.00200	.00200	.00200	.00200
veterinary & medicine	.00245	.00245	.00245	.00245	.00245
telephone	.00025	.00025	.00025	.00025	.00025
death loss	.01667	.01667	.01667	.01667	.01667
Total	.03995	.03836	.03791	.03766	.03740

grown or in areas near large suburban developments. In his study, he assumed an average price of $2.52 per ton and production of seven pounds per head per day with a value of .882 cents per animal day.

Prices received for manure in Imperial Valley reported in the present study were at the low end of the range reported by Hopkin. Assuming a price of $1.50 per ton and seven pounds per head per day, a value of .525 cents per animal day is obtained.

AVERAGE COST FUNCTIONS

Short-run average total cost curves for each of the model feedlots are presented both in terms of "cents per head per day" and in terms of "dollars per ton of feed." These two methods of expressing costs are developed since both are commonly used in the feeding industry.

Cost Functions Expressed in Cents per Head per Day

Cost Functions for Model Feedlots

Short-run average total cost functions for five model feedlots are summarized in Table 9. For a given feedlot there is a maximum output measured in animal days which is equal to the capacity of the feedlot multiplied by the number of days of operation per year assumed to be 360 days.

An alternative measure of output is the number of cattle fed annually for a specified length of feeding period, taken here at 120 days. The maximum output in terms of number of cattle fed 120 days is obtained by dividing the output measured in animal days by 120. (See Table 9.) This measure of output will be used in presenting the cost curves in the following discussion.

Short-run cost curves for the five model feedlots are illustrated in Figure 2. For a given feedlot, costs decline sharply as the utilization of the fixed plant is increased. The feedlot with designed capacity of 7,520 head, for example, has nonfeed costs of 9.70 cents per head per day if 9,000 cattle are fed annually (40 percent of maximum output) as compared with 6.18 cents per head per day if 22,560 cattle are fed annually, the maximum output level for cattle fed 120 days. Data on average variable, fixed

TABLE 9

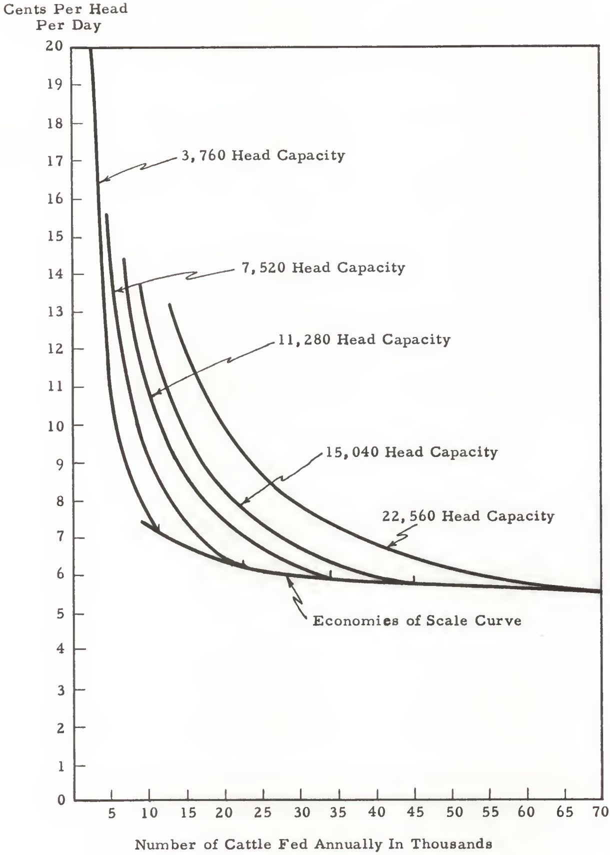
Short-Run Cost Functions for Model Feedlots

Feedlot capacity (C)	Annual fixed cost	Annual variable cost		Maximum output	
		Constant	Per head per day	Animal days (Nd)[a]	Cattle fed 120 days N[b]
	dollars			thousands	actual
3,760	29,922	13,361	.03995	1,353.6	11,280
7,520	49,296	14,193	.03836	2,707.2	22,560
11,280	71,553	15,108	.03791	4,060.8	33,840
15,040	91,628	15,965	.03766	5,414.4	45,120
22,560	131,126	17,736	.03740	8,121.6	67,680

[a] Feedlot capacity multiplied by number of days operated per year (D = 360).

[b] Animal days divided by number of days on feed (d = 120); or feedlot capacity multiplied by maximum number of lots of cattle fed (i.e., $\frac{D}{d} = \frac{360}{120} = 3$).

Figure 2. Economies of Scale Curve for Nonfeed Costs of Operating Model Feedlots With Cattle Fed 120 Days



and total costs for model feedlots operated at various levels are given in Table 10 and form the basis for Figure 2. In actual operation of feedlots it may be difficult to attain the maximum output level due to weather conditions and other considerations. Further, the analysis assumes that rates of gain and death loss do not vary with the number of cattle fed annually. These modifications could be introduced if data were available and might well result in an upturn in the short-run cost curves.[1] The importance of individual nonfeed cost items for the model feedlots operated at maximum output levels is given in Table 11.

The long-run average unit cost curve, or the economies of scale line, is obtained by drawing an "envelope" curve to the short-run cost curves for which capacity of plant was held fixed. (See Figure 2.) Costs at maximum output decline from a level of 7.19 cents for the feedlot with capacity of 3,760 head to a cost of 5.57 cents for the feedlot with capacity of 22,560 head. The curve declines gradually from the second to fifth model feedlot indicating that most economies of scale have been achieved for a feedlot size of 7,520 head capacity and with the associated feed mill of ten tons per hour output.

Comparison of Costs--Model Feedlots and Hopkin Study

The study of feedlots by Hopkin referred to previously provides a basis for comparison of the hypothetical model feedlots with a large sample of actual operating units. In his study, he constructed short-run average cost curves for six different feedlot capacities, working from the average cost position of lots of various sizes. The estimation procedures used are presented in Hopkin's studies and need not be repeated here. A comparison of the costs of the model feedlots and costs derived from his study are given in Table 12 for feedlots operated at 80 percent of capacity.

The costs derived from Hopkin's study are higher by about 1.5 cents per head per day than the costs for the model feedlots. The difference in costs is due primarily to cost of labor, although there are offsetting differences in taxes and death losses, as indicated in Table 13. For labor,

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[1] For a further discussion of this point, see the discussion by Hopkin, Economies of Size in the California Cattle-Feeding Industry of California, op. cit., p. 424.

TABLE 10

Nonfeed Costs per Head per Day for Model Feedlots Operated at Various Percentages of Maximum Annual Output 3 Lots of Cattle Fed 120 Days

Feedlot designed capacity	Percent of maximum output a/				
	100	80	60	40	20
	cents per head per day				
3,760 head					
Fixed	2.21	2.76	3.69	5.53	11.06
Variable	4.98	5.23	5.64	6.46	8.93
Total	7.19	7.99	9.33	11.99	19.99
7,520 head					
Fixed	1.82	2.28	3.04	4.55	9.10
Variable	4.36	4.49	4.71	5.15	6.46
Total	6.18	6.77	7.75	9.70	15.56
11,280 head					
Fixed	1.76	2.20	2.94	4.41	8.81
Variable	4.16	4.26	4.41	4.72	5.65
Total	5.92	6.46	7.35	9.13	14.46
15,040 head					
Fixed	1.69	2.12	2.82	4.23	8.46
Variable	4.06	4.13	4.26	4.50	5.24
Total	5.75	6.25	7.08	8.73	13.70
22,560 head					
Fixed	1.61	2.02	2.69	4.04	8.08
Variable	3.96	4.01	4.10	4.28	4.83
Total	5.57	6.03	6.79	8.32	12.91

a/ The number of cattle fed for respective feedlots assuming 3 lots per year is as follows:

Feedlot designed capacity	Percent of maximum output				
	100	80	60	40	20
	number of head				
3,760	11,280	9,024	6,768	4,512	2,256
7,520	22,560	18,048	13,536	9,024	4,512
11,280	33,840	27,072	20,304	13,536	6,768
15,040	45,120	36,096	27,072	18,048	9,024
22,560	67,680	54,144	40,608	27,072	13,536

TABLE 11

Individual Nonfeed Costs Expressed in Cents per Head per Day for Model Feedlots Operated at Capacity, for 360 Days

Item	Feedlot capacity--number of head				
	3,760	7,520	11,280	15,040	22,560
	cents per head per day				
Fixed costs					
Management & office	.63	.55	.55	.55	.52
Taxes, insurance & interest	.71	.56	.53	.50	.47
Depreciation of equip.	.32	.19	.16	.13	.12
Depreciation & repair of other equipment	.55	.52	.52	.51	.50
Total	2.21	1.82	1.76	1.69	1.61
Variable costs					
Labor, excluding office	1.91	1.65	1.56	1.51	1.47
Electricity	.45	.32	.27	.26	.23
Equipment repairs	.19	.11	.10	.08	.07
Gasoline & oil	.20	.20	.20	.20	.20
Veterinary & medicine	.49	.36	.32	.30	.28
Telephone	.07	.05	.04	.04	.04
Death loss	1.67	1.67	1.67	1.67	1.67
Total	4.98	4.36	4.16	4.06	3.96
Total cost	7.19	6.18	5.92	5.75	5.57

TABLE 12

Comparison of Nonfeed Costs, Model Feedlots and Hopkin Study, for Feedlots at 80 Percent of Capacity for 360 Days

Hopkin study a/		Present study b/	
Average capacity (head)	Gross non-feed costs	Capacity (head)	Nonfeed costs
number	cents	number	cents
486	11.0	--	--
1,498	9.5	--	--
3,205	8.6	3,760	8.0
6,479	8.3	7,520	6.8
10,531	8.0	11,280	6.5
18,053	7.9	15,040	6.2
		22,560	6.0

a/ Hopkin, John A., "Economics of Size in Feed Lots," op. cit. Data estimated from Figure 1, p. 422, for net costs associated with a feeding ratio of 2.40 (or 80 percent of capacity) plus allowance for manure of $.009 per head per day giving gross costs which is the level used in the present study.

b/ See Table 10 for costs associated with mills operated 8 hours per day (or 80 percent of capacity).

TABLE 13

Comparison of Individual Cost Items, Model Feedlot and Hopkin Study, for a Feedlot with Approximately 7,000 Head Capacity, Operated at 60 Percent of Capacity for 360 Days

Item	Hopkin study a/ Feedlot with average capacity of 6,479 head and operated at 57% of capacity	Present study b/ Feedlot with capacity of 7,520 head and operated at 60% capacity
	cents per head per day	
Labor, excluding office	3.81[b/]	1.83
Depreciation & repair of equipment & buildings	1.10	1.31
Taxes	.63	.18
Interest on investment	1.26	.57
Insurance	.28	.18
Fuel and power	.57	.59
Veterinary & medicine	.31	.44
Death loss	.99	1.67
Administration & overhead	.35	.95
Gross nonfeed costs	9.30	7.72

a/ Hopkin, John A., "Economies of Scale in Feed Lots," *op. cit.*

b/ Includes cost of operator's labor.

Hopkin included the operator's labor in the category "labor, excluding office," whereas in this study it was included in "administration and overhead." Combining these two categories still results in a cost difference of 1.38 cents per head per day. The assumption used in the model feedlots as to labor efficiency with lots operated at less than maximum output levels may underestimate the labor costs of operating feedlots.

Costs with Feeding Periods of 120, 144, and 180 Days

The average cost per head per day varies with the level of utilization of a given feedlot measured in animal days (Nd). Previous analyses have presented relationships assuming a length of feeding period (d) of 120 days. Similar relationships could easily be developed for different "days on feed" within reasonable limits. The cost per head per day would be equal for a given utilization of a feedlot. For example, at capacity level the value of Nd for the feedlot with designed capacity of 7,520 equals 2,707,200 animal days. This could be achieved with 22,560 cattle fed 120 days or 15,040 cattle fed 180 days. The cost per head per day would equal 6.2 cents for both situations.[1]

The cost per head for the entire feeding period, however, would vary directly with the number of days on feed. This relationship is illustrated in Figure 3, section B, with cost expressed in dollars per head.

Costs with 120-Day Feeding Period and 1, 2, and 3 Lots per Year

In previous sections costs have been presented assuming 3 lots of cattle are fed per year for a 120-day feeding period. In this section nonfeed costs per head per day are presented for feeding 1, 2, and 3 lots of cattle per year. The model feedlot with 7,520 head capacity is used to illustrate these cost comparisons as given in Figure 3, section A.

In this diagram, "number of head per lot" is plotted on the horizontal axis rather than total fed per year. In this analysis the cost per head per day for feeding a given number of cattle annually is equal regardless of the number of lots of cattle fed. For example, the cost per head per day

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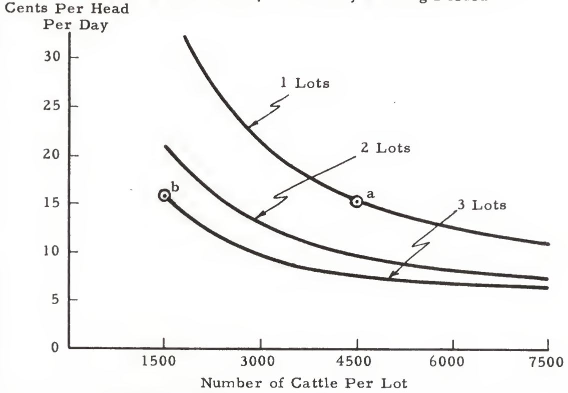
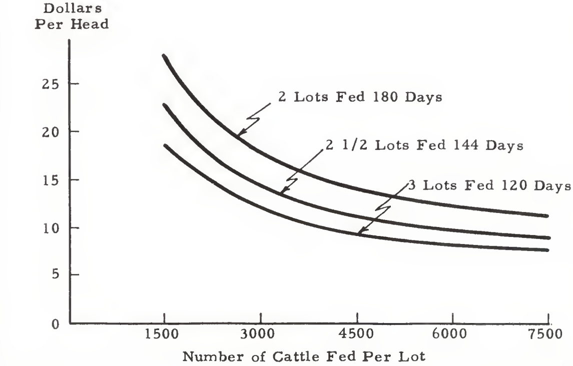
[1] The cost per head per day may be slightly higher for animals fed the shorter period in actual feedlot operations due to costs involved in handling more lots of cattle.

Figure 3. Short-Run Average Cost Curves for Model Feedlot with 7520 Head Capacity

Section A: Average Cost Curves with One, Two and Three Lots of Cattle Feed Annually -- 120 Day Feeding Period



Section B: Cost Per Head For Feeding Periods of 120, 144, and 180 Days



for feeding 4,500 cattle in one lot (point a) equals the cost for feeding 3 lots of 1,500 cattle (point b). However, with an increase in the number of cattle fed per year, costs decline substantially. The cost per head per day for 1 lot of 6,000 cattle equals 12.6 cents as compared with 6.8 cents for 3 lots of 6,000 cattle.

Cost Functions Expressed in Dollars per Ton of Feed Fed

Costs with 120-Day Feeding Period, 3 Lots per Year

Short-run cost functions with costs expressed as a function of dollars per ton of feed fed are given in Table 14 for the five model feedlots. These costs are directly related to those given in Table 10 expressed in cents per head per day. This follows from the assumption that cattle are fed a ration of 26.6 pounds per day (.0133 tons), and the conversion is made utilizing the relationship given in equation (6).

Nonfeed costs per ton for the five model feedlots are given in Table 15 for varying percentages of maximum annual output. As would be expected, the general pattern of cost relationships is identical to those for nonfeed costs expressed in cents per head per day.

Comparison of Costs--Model Feedlots and Moran Study

A study of Arizona feedlots by Moran provides a rough basis for comparison of nonfeed costs.[1] Nonfeed costs are indicated in Table 16 for a range in tons fed annually from "under 500" to "12,500 and up." Nonfeed costs are indicated at $5.56 for the feedlots feeding 12,500 tons and over. As a rough comparison, the data presented in Table 15 for the feedlot with maximum yearly output of 18,000 tons operated at 80 percent of maximum output equaled $6.01 per ton.

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[1] Moran, L. J., Nonfeed Costs of Arizona Cattle Feeding, Arizona Agricultural Experiment Station, Tech. Bul. 138, December 1959.

TABLE 14

Short-Run Cost Functions for Model Feedlots with Variable Costs Expressed as a Function of Dollars per Ton Fed

Feed mill output per hour	Annual fixed cost	Annual variable cost		Maximum output
		constant	per ton fed a/	tons of feed b/
	dollars			actual
5	29,922	13,361	3.00	18,000
10	49,296	14,193	2.88	36,000
15	71,553	15,108	2.85	54,000
20	91,628	15,965	2.83	72,000
30	131,126	17,736	2.81	108,000

a/ Converted from cost per head per day (Table 9) by dividing by .0133 or the number of tons of feed fed per head per day (See equation 6).

b/ Feed mill output per hour multiplied by 10 (hours per day) and 360 (days per year).

TABLE 15

Nonfeed Costs per Ton of Feed Fed for Model Feedlots Operated at Various Percents of Maximum Output

Feed mill maximum yearly output	Percent of maximum output				
	100	80	60	40	20
	dollars per ton fed				
18,000 tons					
Fixed	1.66	2.08	2.77	4.16	8.32
Variable	3.74	3.93	4.24	4.86	6.71
Total	5.40	6.01	7.01	9.02	15.03
36,000 tons					
Fixed	1.37	1.71	2.29	3.42	6.84
Variable	3.28	3.38	3.54	3.87	4.86
Total	4.65	5.09	5.83	7.29	11.70
54,000 tons					
Fixed	1.32	1.66	2.21	3.32	6.62
Variable	3.13	3,20	3.32	3.55	4.25
Total	4.45	4.86	5.53	6.87	10.87
72,000 tons					
Fixed	1.27	1.59	2.12	3.18	6.36
Variable	3.05	3.11	3.20	3.38	3.94
Total	4.32	4.70	5.32	6.56	10.30
108,000 tons					
Fixed	1.21	1.52	2.02	3.04	6.08
Variable	2.98	3.01	3.08	3.22	3.63
Total	4.19	4.53	5.10	6.26	9.71

TABLE 16

Nonfeed Costs per Ton of Feed Fed by Size of Feedlot

Tons of feed fed			Average expenses per ton of feed fed (dollars)							
Range (tons)	Average (tons)	No. feed-lots	Total	Invest-ment	Labor	Non-labor wages	Death loss	Vet. & Med.	Misc.	No. head fed
Under 500	279	15	$18.30	$11.65	$3.10	$2.60	$.51	$.24	$.20	238
500-999	754	16	13.09	6.76	2.80	2.56	.66	.26	.05	502
1,000-2,499	1,674	19	11.47	6.08	2.38	1.95	.49	.35	.22	957
2,500-4,999	3,544	14	8.93	4.73	2.09	1.24	.48	.26	.13	1,749
5,000-12,499	8,510	16	6.07	3.27	1.29	.83	.45	.12	.11	5,456
12,500 and up	21,974	10	5.56	2.77	1.14	.91	.44	.18	.12	16,545
All	5,039	90	$ 7.38	$ 3.74	$1.48	$1.40	$.45	$.19	$.12	3,451

Source: Moran, L. J., Nonfeed Costs of Arizona Cattle Feeding, Arizona Agricultural Experiment Station, Tech. Bul. 138, December 1959.

SUMMARY AND CONCLUSIONS

Five model feedlots with designed capacities of 3,760, 7,520, 11,278, 15,038, and 22,556 head, respectively, were developed to determine the behavior of average costs associated with scale of operation and with level of capacity at which individual feedlots are operated. Feed mill construction costs were obtained for mills with hourly capacity of 5, 10, 15, 20, and 30 tons. Associated costs of feed yards, storage facilities, feeding equipment, and other equipment were estimated. For each feedlot size, average unit costs were calculated for mills operated between 20 and 100 percent of maximum annual output. These short-run plant cost curves were then used to develop an economies of scale curve for large commercial feeding operations.

The importance of operating feedlots at near maximum output levels is illustrated by the fact that nonfeed costs for a feedlot operated at 80 percent of capacity are less than half those costs of a feedlot operated at 20 percent of capacity. Also, the level of nonfeed costs declines, for a given percent of maximum output, as the size of the feedlot increases. For a feedlot operated at 80 percent of maximum output, for example, the nonfeed costs of the feedlot with capacity of 22,556 head was only 75 percent of the level of costs for the feedlot with 3,760 head capacity.

The trend toward larger feedlots is justified by the economies of scale of feedlot operations. These cost advantages can be fully attained only if the feedlots are used to capacity. California cattle feeding is dependent on the inshipment of feeders from other areas to keep feedlots filled at high levels of lot capacity. Custom feeding is common in large lots although the extent of packer-owned or livestock producer-owned cattle is not known. This arrangement does allow feedlot operators to utilize the feedlot to a higher level of capacity and thus take advantage of lower nonfeed costs for cattle owned and custom fed.

APPENDIX A

ESTIMATION OF FEED YARD CONSTRUCTION COSTS

Construction costs for feed yards including water tanks were assumed to equal approximately $20 per head capacity. This figure was based on (1) reported construction costs of Imperial Valley feeders which ranged from $7 to $30 per head, with an average of $19; and (2) an estimate of construction costs based on material reported by Albaugh, et al.[1] The following method of estimating costs provides information as to how costs vary depending on the operator's decision as to feeding space per head, the number of head per pen, and the amount of loafing space per head.

The length of the manger (X_1) depends upon the feedlot operator's decision as to the feeding space per head and the number of head per pen; or

$$X_1 = (\text{feeding space per head}) \times (\text{number head per pen}).$$

The width of the pen (X_2) is related to the loafing space per head, the number of head per pen, and the length of the pen; or

$$X_2 = \frac{(\text{loafing space per head}) \times (\text{number head per pen})}{X_1}$$

The costs associated with the length of manger (X_1) includes the cost per foot of manger (b_1); the cost per foot of truck lane of cement (b_2) if required; and the cost per foot of corral fence (b_3). A factor of 2 is associated with b_3 to allow for posts along the manger and the rear of the pen, and a double fence along the rear of the pen. The cost per foot (b_1, b_2, b_3) is indicated in Appendix Table A1.

The cost associated with the width of the pen (X_2) includes fencing (exclusive of gates), and is multiplied by a factor of two to provide the required fencing for each side.

The cost per pen (C) may be expressed as follows:

$$C = a_1 + (b_1 + b_2 + 2b_3)\,X_1 + 2b_3\,X_2$$

where a_1 = fixed costs per pen (water tanks, platforms, and gates),

b_1 = cost per foot of feed manger and standing platform,

b_2 = cost per foot of truck feeding lane (cement),

b_3 = cost per foot of corral fence (including posts).

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[1] Albaugh, Reuben, C. F. Kelley and H. L. Belton, Beef Handling and Feeding Equipment, California Agri. Expt. Sta. Circular 414, Rev. January 1958.

The costs associated with given levels of X_1 and X_2 may be expressed as follows:

$$C = 331.25 + (4.53 + 2.59 + 2.24)\ X_1 + 2.24\ X_2$$

In cost calculations, the loafing space per head was assumed to equal 220 square feet per head. The costs associated with varying levels of feeding space per head and number of head per pen are indicated in Appendix Table A2. Cost data are given for construction including and excluding a cement truck lane.

APPENDIX TABLE A1

Construction Costs for a Small Four-Pen Feedlot, Excluding Work Corral, Scales, Shades, Water Pipe and Well[a]

Item		Cost for 4 pens	Cost per pen	Cost per lineal foot
			dollars	
Fixed costs (a_1)				
2 tank platforms 19' x 32', 6" thick				
cement 23 cu. yd. @ $14/yd.	$322.00			
labor 25% of cement cost	80.50	402.50	100.63	--
2 water tanks 3' x 16' @ $150		300.00	75.00[b]	--
Gates - 11 (5-12' and 6-14')	415.00			
labor--50% of material cost	207.50	622.50	155.62	--
Total		1,325.00	331.25	--
Feed manger and standing platform (b_1)				
paved manger bottom and standing platform				
cement--14' x 4" thick = 0.173 cu. yd. @ $14/yd.		1,162.00[c]	--	2.43
labor--25% of cement cost		290.50	--	60
manger				
material--$1/lineal foot		480.00[c]	--	1.00
labor--50% of material cost		240.00	--	.50
Total		2,172.50	543.12	4.53
Truck lane for feeding (b_2)				
cement--8' x 6" thick = 0.148 cu. yd. @ $14/yd.		994.00[c]	--	2.07
labor--25% of cement cost		248.50	--	.52
Total		1,242.50	310.63	2.59
Corral fence and posts (b_3)				
posts (redwood or treated)				
6" x 6" x 8' 172 @ $2		344.00	86.00	.21[d]
labor--50% of material cost		172.00	43.00	.11
corral fence (Douglas fir)				
2" x 6" x 16' (412) = 6592 bd. ft. @ $120/m		791.00	197.75	.49[d]
labor--50% of material cost		395.50	98.88	.25
hardware		98.88	24.72	.06
Total		1,801.38	450.35	1.12
Total Cost		6,541.38	1,635.35	--

[a] Material requirements and costs for 4-pen feedlot are based on data reported by Albaugh, et al., op. cit.

[b] Water tanks are used for two pens and cost equals one-half the price of one tank.

[c] Cost for 4 pens assuming 120' feed mangers per pen, as reported by Albaugh, Kelly, and Belton.

[d] Cost per lineal foot assuming 400 lineal feet of posts and fencing per pen (excluding gates).

APPENDIX TABLE A2

Feed Yard Construction Costs per Head Associated with Three Levels of Feeding Space per Head and Three Levels of Number of Head per Pen[a]

Feeding space per head in feet	Width of pen (X_2)	Number of head per pen					
		50		100		150	
		Length of manger (X_1)	Cost per head	Length of manger (X_1)	Cost per head	Length of manger (X_1)	Cost per head
	feet	feet	dollars	feet	dollars	feet	dollars
With cement truck lane							
1.5	147	75	$27	150	$21	225	$18
2.0	110	110	30	200	24	--	--
2.5	88	125	34	250	29	--	--
Without cement truck lane							
1.5	147	75	23	150	17	225	15
2.0	110	110	26	200	19	--	--
2.5	88	125	28	250	22	--	--

a/ Based on 220 square feet of loafing space per head.

APPENDIX TABLE B1

Operating Conditions on a Sample of 10 Large Commercial Feedlots in Imperial Valley, California, 1960

Item	Unit	Capacity of feed mill in tons per hour				Average of all feedlots
		10-20		30 and over		
		Low	High	Low	High	
Mill operation	hours	2	10	3	10	5.8
Feedyard capacity						
present	thousand head	2	12	6	22	10.9
planned	thousand head	4	12	15	22	12.6
Cattle fed per year[a]	thousand head	6	30	18	62	27.3
Ratio: number fed / present feedlot capacity	ratio	1.8	2.9	2.0	2.9	2.5
Ratio: planned feedlot capacity / mill capacity	ratio	.44	1.00	.58	.98	.76
Grain storage						
total	thousand tons	1	4	.5	20	6.4
number days' supply[b]	days	19	117	8	167	64
Mixed feed storage						
total	tons	6	40	15	250	49
supply per hour of mill output	hours	.5	3	.5	5	1.7

[a] Standardized to a 120-day feeding period.

[b] Assuming 18 pounds of grain and meal per animal per day for the maximum reported number of head on feed at any one time.

APPENDIX TABLE B2

Cost per Head per Day for Selected Items, Imperial Valley Study, 1960[a]

Item	Range in cost	Average cost
	cents	
Electricity	0.12 - .32	0.22
Telephone	.32 - .21	.06
Gas and oil	.06 - .43	.20
Veterinary and medicine	.25 - .80	.43
Taxes	.07 - .47	.26
Insurance	.13 - .62	.27
Interest	.31 - .89	.54
Labor, excluding office	1.16 - 1.98	1.68
Management and office	.56 - 1.92	1.06

a/ Costs normalized to a 120-day feeding period.

APPENDIX TABLE B3

Investment Costs for Feedlot with Designed Capacity of 3,760 Head and Feedmill with 5 Tons per Hour Capacity

Item	Number	Description	Capacity	H. P. of motors	Total cost
					dollars
Feed yards	--	Cost approx. $20/head cap.	3,760 head	--	75,000
Grain and hay storage					
Grain	--	Cement floors	1,200 T	--	18,000
Hay	--	Pole and timber constr.	250 T	--	2,500
Total					20,500
Office and scales					
Office	--	--	--	--	4,500
Scales, livestock	1	8' x 14'	5 T	--	810
Scales, truck	1	10' x 30'	25 T	--	4,500
Total					9,810
Feed formulating equipment and buildings					
Hay mill and conveyor		24" mill, precutter, baled hay conveyor, blower, dust collector and bldg.			
mill and conveyor	1		3-4 T/hr.	75 1/2	12,000
dust collector	1			1	6,000
Grain conveyor from storage					
bucket elevator	1	--	30 T/hr.	5	3,500
distributing head	1	6 way head	--	--	1,000
elevator pit	1	--	--		2,500
auger	3	--	30 T/hr.	6	4,500
Grain roller and blower					
roller	1	18"	2 1/2-3 T/hr.	25	4,800
blower	1	11"		10	1,700
Percentage mill					
concentrate bins (28 T)	3	incl. motors for feed del.	3-9 T/hr.	3/4	11,200
hay bin (4 T)	1	incl. motors for feed del.	1-6 T/hr.	3/4	
collecting auger	1	--	5-15 T/hr.	1/2	1,000
premix bin	1	incl. motor for feed del.	1/4 T/hr.	1/4	700
premixer	1	incl. motor	250 lbs.	1 1/2	700
premix bucket elevator & scale	1	--	--	1/2	1,000
tachometer	1	--	--	--	1,200
Molasses blending, feed conveyors, and finished feed bins					
tank, pump, etc.	1	--	5,000 gal.	3/4	3,300
hot water coil and heater	1	incl. circulating pump	--	1/2	1,200
dry feed elevator	1	moves feed-dry blender to surge bin	--	1 1/2	2,200
surge bin	1	--	5-10 T/hr.	3/4	1,800
wet blender	1	--	5 T/hr.	5	1,200
blending room	1	--	--	--	3,500
finished feed elevator	1	--	5-10 T/hr.	2	2,500
finished feed bins	1	5-ton bin	5 T	--	3,000
bin meter	1	--		--	150
Total					70,650
Feeding and miscellaneous equipment					
livestock squeeze	1	--	--	--	450
sprayer	1	--	50 gal.	--	640
pickup truck	1	--	--	--	2,200
feeding trucks					
truck	1	--	2 T	--	3,400
automatic feeder	1	300 cu. ft.--mounted on truck	--	--	2,600
tractor and scoop	1		40 h.p.	--	5,000
hay trailers and loader	--	--	--	--	2,900
Total					17,190
TOTAL					$193,150

APPENDIX TABLE B4

Investment Costs for Feedlot with Designed Capacity of 11,280 Head and Feedmill with 15 Tons per Hour Capacity

Item	Number	Description	Capacity	H. P. of motors	Total cost dollars
Feed yards	--	Cost approx. $20/head cap.	11,280 head	--	$225,000
Grain and hay storage					
Grain	--	Cement floors	3,600 T	--	54,000
Hay	--	Pole and timber constr.	1,000 T	--	7,500
Total					61,500
Office and scales					
Office	--	--	--	--	4,500
Scales, livestock	1	8' x 22'	10 T		1,500
Scales, truck	1	10' x 60'	50 T		10,000
Total					16,000
Feed formulating equipment and buildings					
Hay mill and conveyor		30" mill, precutter, baled hay and chopped hay conveyors, dust collector & bldg.			
Mill and conveyor	1		5-6 T/hr.	123	17,300
Dust collector	1			1 1/2	8,000
Grain conveying from storage					
Bucket elevator	1	--	30 T/hr.	5	3,500
Distributing head	1	6 way head			1,000
Elevator pit	1	--			2,500
Auger	4	--	30 T/hr.	8	6,500
Grain roller and blower					
Roller	1	36"	6-8 T/hr.	50	8,100
Blower	1	11"		25	3,800
Percentage mill					
Concentrate bins (36 T/bin)	4	Including motors for feed delivery	3-9 T/hr.	3/4	13,900
Hay bin (6 T/bin)	1	Including motors for feed delivery	1-6 T/hr.	3/4	
Collecting auger	1		5-15 T/hr.	1/2	1,000
Premix bin	1	Including motor for feed delivery	1/4 T/hr.	1/4	700
Premixer	1	Including motor	250 lbs.	1 1/2	700
Premix bucket elevator & scale	1	--	--	1/2	1,000
Tachometer	1	6 senders, sender stations and counters	--	--	1,200
Molasses blending, feed conveying and finished feed bins					
Tank, pump, etc.	1	--	15,000 gal.	3/4	5,000
Hot water coil and heater	1	Including circ. pump	--	1/2	1,600
Dry feed elevator	1	Move feed dry blender to surge bin	--	1 1/2	2,400
Surge bin	1	--	15-20 T/hr.	1 1/2	2,400
Wet blender	1	--	15-20 T/hr.	15	1,800
Blending room and storage	1	--	--	--	4,500
Finished feed elevator	1	--	15-20 T/hr.	5	3,800
Finished feed bins	3	5 ton bins	15 T	--	6,500
Bin meter	3	--	--	--	450
Total					97,650
Feeding and Miscellaneous Equipment					
Livestock squeeze	2	--			900
Sprayer	1	--	150 gal.		680
Pickup truck	1	--			2,200
Feeding trucks					
Truck	2		2 T		6,800
Automatic feeder	2	370 cu. ft.--mounted on truck	--		6,000
Tractor and scoop	2		40 h. p.		10,000
Hay trailers and loader					3,300
Total					29,880
TOTAL					$430,030

APPENDIX TABLE B5

Investment Cost for Feedlot with Designed Capacity of 15,040 Head and Feedmill with 20 Tons Per Hour Capacity

Item	Number	Description	Capacity	H. P. of motors	Total cost
					dollars
Feed yards	--	Cost approx. $20/head cap.	15,040	--	$300,000
Grain and hay storage					
Grain	--	Cement floors	3,600 T	--	67,200
Hay	--	Pole and timber construction	1,000 T	--	10,000
Total					77,200
Office and scales					
Office	--	--	--	--	4,500
Scales, livestock	1	8' x 22'	10 T	--	1,500
Scales, truck	1	10' x 60'	50 T	--	10,000
Total					16,000
Feed formulating equipment and buildings					
Hay mill and conveyor		36" mill, precutter, baled hay and chopped hay conveyors, dust collector and building			
Mill and conveyor	1		7-9 T/hr.	155	20,800
Dust collector	1			1 1/2	8,000
Grain conveyor from storage					
Bucket elevator	1	--	30 T/hr.	5	3,500
Distributing head	1	6 way head	--	--	1,000
Elevator pit	1	--	--	--	2,500
Auger	4	--	30 T/hr.	8	6,750
Grain roller and blower					
Roller	2	30", 4-6 T/hr. per roller	8-12 T/hr.	80	12,800
Blower	2	9"	--	30	4,400
Percentage mill					
Concentrate bins (36 T)	4	Incl. motors for feed delivery	5-15 T/hr.	1	17,000
Hay bin (6 T)	1	Incl. motors for feed delivery	2-8 T/hr.	1	
Collecting auger	1	--	15-25 T/hr.	1	1,500
Premix bin	1	Incl. motor for feed delivery	1/4 T/hr.	1/4	800
Premixer	1	Incl. motor	300 lbs.	1 1/2	900
Premix bucket elevator and scale	1	--	--	1/2	1,000
Tachometer	1	--	--		1,200
Molasses blending, feed conveyors, and finished feed bins					
Tank, pump, etc.	1	--	20,000 gal.	1 1/2	6,500
Hot water coil and heater	1	Incl. circulating pump	--	1	1,800
dry feed elevator	1	Moves feed-dry blender to surge bin	--	3	2,500
Surge bin	1	--	15-20 T/hr.	1 1/2	2,400
Wet blender	1	--	15-20 T/hr.	20	1,800
Blending room and storage	1	--	--	--	5,000
Finished feed elevator	1	--	15-20 T/hr.	5	3,800
Finished feed bins	4	5 ton/bin	20 T	--	8,000
Bin meter	4	--	--	--	600
Total					114,550
Feeding and misc. equipment	4				
Livestock squeeze	2	--	--	--	900
Sprayer	1	--	200 gal.	--	700
Pickup truck	1	--	--	--	2,200
Feeding trucks					
Truck	2	--	2 T	--	6,800
Automatic feeder	2	370 cu. ft. mounted on truck		--	6,000
Tractor and scoop	2	40 h. p.	--		10,000
Hay trailers and loader	--	--	--		3,300
Total					29,900
TOTAL					$537,650

APPENDIX TABLE B6

Investment Costs for Feedlot with Designed Capacity of 22,560 Head and Feedmill with 30 Tons Per Hour Capacity

Item	Number	Description	Capacity	H. P. of motors	Total cost
					dollars
Feed yards	--	Cost approx. $20/head cap.	22,560	--	$450,000
Grain and hay storage					
Grain	--	Cement floors	7,200 T	--	100,800
Hay	--	Pole and timber construction	1,500 T	--	15,000
Total					115,800
Office and scales					
Office	--	--	--	--	4,500
Scales, livestock	1	8' x 22'	10 T		1,500
Scales, truck	1	10' x 60'	50 T		10,000
Total					16,000
Feed formulating equipment and building					
Hay mill and conveyor					
Mill and conveyor	1	42" mill, precutter, baled hay and chopped hay conveyors, dust collector and building	14-16 T/hr.	242	28,700
Dust collector	1		--	1 1/2	8,000
Grain conveying from storage					
Bucket elevator	1	--	30 T/hr.	5	3,500
Distributing head	1	6 way head	--	--	1,000
Elevator pit	1	--	--	--	2,500
Auger	4	--	30 T/hr.	8	7,250
Grain roller and blower					
Roller	2	36" 6-8 T/hr. per roller	12-16 T/hr.	100	16,200
Blower	2	11"	--	50	7,200
Percentage mill					
Concentrate bins (36 T)	4	Incl. motors for feed delivery	15-25 T/hr.	1	20,000
Hay bin (6 T)	2	Incl. motors for feed delivery	4-10 T/hr.	1	
Collecting auger	1	--	25-30 T/hr.	1 1/2	2,000
Premix bin	1	Incl. motor for feed delivery	.4 T/hr.	1/2	1,100
Premixer	1	Incl. motor	300 lbs.	1 1/2	900
Premix bucket elevator & scale	1	--	--	1/2	1,300
Tachometer	1	--	--	--	1,200
Molasses blending, feed conveying and finished feed bins					
Tank, pump, etc.	2	15,000 gal. tanks	30,000 gal.	2	10,000
Hot water coil and heater	2	Incl. circulating pump	--	1	3,200
Dry feed elevator	1	Moves feed-dry blender to surge bin		3	2,800
Surge bin	1	--	30 T/hr.	2	3,600
Wet blender	1	--	30 T/hr.	30	2,400
Blending room and storage	1	--	--	--	6,000
Finished feed elevator	1	--	30 T/hr.	7 1/2	5,800
Finished feed bins	6	5 T/bin	30 T	--	10,000
Bin meter	6	--	--	--	800
Total					145,450
Feeding and misc. equipment					
Livestock squeeze	3	--	--	--	1,350
Sprayer	1	--	300 gal.	--	800
Pickup truck	1	--	--	--	2,200
Feeding trucks					
Truck	3	--	2 T	--	10,200
Automatic feeder	2	370 cu. ft. mounted on truck	--	--	9,000
Tractor and scoop	3	40 h. p.	--	--	15,000
Hay trailers and loader	--	--	--	--	4,100
Total					42,650
TOTAL					$769,900